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# NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP) DATA REPORT FOR TAPE VL0009

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## SUMMARY

Atmospheric trace constituents in the upper troposphere and lower stratosphere are being measured as part of the Global Atmospheric Sampling Program (GASP), using fully automated air sampling systems on board the NASA CV-990 research aircraft and four commercial B-747 aircraft in routine airline service.

This report is the eighth of a series of reports which describes the currently available GASP data, including flight routes and dates, instrumentation, data processing procedures, and data tape specifications. In-situ measurements of atmospheric ozone, carbon monoxide, condensation nuclei, and clouds, and related meteorological and flight information obtained during Pan American World Airways Fiftieth Anniversary Flight on October 28-31, 1977 are reported. These data are now available from the National Climatic Center, Asheville, North Carolina. In addition to the GASP data, tropopause pressures obtained from time and space interpolation of National Meteorological Center (NMC) archived data for the dates of the flights are included.

## INTRODUCTION

This report announces the availability of atmospheric trace constituent data obtained at altitudes from 6 to 13.7 km during four flights of the GASP-equipped B-747SP, N533PA, on October 28, 29, 30, and 31, 1977.

The objectives of the NASA Global Atmospheric Sampling Program are to provide baseline data of selected atmospheric constituents in the upper troposphere and lower stratosphere and to document and analyze these data to 1) provide a better understanding of the dynamics of the atmosphere in the region where commercial aircraft fly, and 2) provide initial value boundary conditions for atmospheric models being used to assess potential adverse effects from aircraft exhaust emissions on the natural atmosphere.

The GASP program began in 1972 with a feasibility study of the concept of using commercial airliners in routine service to obtain atmospheric data. Since then, this program has progressed from design and acquisition of hardware to collecting global data on a daily basis (refs. 1-6). Fully automated GASP systems have been operated on a United Airlines B-747, two Pan American World Airways B-747's, a Qantas Airways of Australia B-747, and the NASA CV-990 research aircraft. The GASP system design, the measurement instruments, the on-board computer for automatic control and data management, and system maintenance procedures are described in references 7 and 8.

This report is the eighth in a series of reports to announce the availability of GASP data from the National Climatic Center, Asheville, North Carolina, 28801. Data for March 1975 through December 1976 are archived on tapes VL0001-VL0008 (refs. 9-15). For each of these tapes, the time periods covered, and the GASP aircraft from which data are archived are identified in table I. Analyses of GASP data are reported in references 16-23. On tape VL0009, data are reported from Pan Am's Fiftieth Anniversary around-the-world-via-the-poles flight flown by the GASP-equipped B-747SP, N533PA, on October 28-31, 1977.

## DATA ACQUISITION

For each GASP flight, data acquisition begins on ascent through the 6 km altitude flight level, and terminates on descent through 6 km. A complete GASP sampling cycle is 60 minutes, divided into 12 five minute sampling segments. During alternate segments (at 10 minute intervals), air sample data are recorded for all instruments. During the intervening segments the system is in one of six different calibration cycles to allow for in-flight checks on instrument operation (if required). Whenever any calibration cycle is not needed for a given instrument, that instrument acquires air sample data during the segment. For normal GASP sampling a 16 second recording is made at the end of each five minute sampling segment. However, because of the special nature of the Fiftieth Anniversary flight, the GASP data recorder was operated continuously, resulting in data records at four second intervals for these flights.

Cassette tapes, on which the data are recorded onboard the aircraft in serial format, are transcribed to computer-compatible form for data reduction. At this stage, laboratory instrument calibration information required for data processing is included, redundant and non-usable data are removed, and the data are re-transcribed to final form and units. On the GASP archive tapes, the data are grouped by aircraft and identified by flights with the airports of

departure and arrival designated by the standard three-letter airport code (ref. 24). Detailed specifications and formats for the GASP data are given in Appendix A. Data for each flight begins with an FLHT record (table A-I) to provide flight identification information. This record is followed by a series of DATA records (table A-II), one for each recording made during the flight.

## MEASUREMENTS

For each in-situ constituent measurement, an instrument ID number is given in the FLHT record for each flight for which constituent data are available; otherwise, ID = 'M'. In addition, each measurement has an associated TAG in each DATA record. If TAG = 'M', data are not available for that record, and the data field has been set equal to zero.

### Ozone

Ozone measurements are made using an ultraviolet absorption ozone photometer (ref. 25). The concentration of atmospheric ozone is determined by measuring the difference in intensity of an ultraviolet light beam which alternately passes through the sample gas and an ozone-free zero gas (generated within the instrument). The instrument output is digital, and the register is up-dated at the end of each 20 second measuring cycle. The range of this instrument is from 3 to 20,000 ppbv (parts per billion by volume), with a sensitivity of 3 ppbv. Data from flight tests of the instrument are given in reference 2.

Prior to February 1977, GASP ozone instruments were checked (over the range 0 to 1000 ppbv) against an ozone generator which was calibrated at 1000 ppbv by the one percent neutral buffered potassium iodide (KI) method (ref. 26). Based on the average of these KI calibrations the GASP ozone instruments read the correct ozone concentrations of an air sample at 1 atmosphere pressure and 25 degrees C when the span is set at 58200.

Recent laboratory studies comparing ozone measurement techniques (refs. 27 and references therein) have reported that the KI method may actually give ozone levels which are from 10 to 30 percent high depending on the details of the procedure used. Because of this uncertainty of the KI procedure as a standard for ozone measurements, GASP ozone instruments are now calibrated by comparison with a commercial U. V. photometer maintained at Lewis as a transfer standard. This transfer standard is periodically (about every 6 months) calibrated against the Jet Propulsion Laboratory 5 meter path length U. V. photometer (ref. 27).

With the span setting of the transfer standard and the GASP ozone instruments set at 58200, the JPL calibrations indicate that the GASP data are 9 percent high. To date these span settings have not been readjusted.

In-flight monitoring of the ozone instrument includes measurement of the instrument zero by flowing the sample through a charcoal filter external to the instrument, and measurement of the electronic span setting and control frequencies. The instruments are not calibrated in-flight with an ozone calibration gas due to the difficulty of generating a precisely known ozone concentration in the flight system. Periodic checks for calibration consistency are performed in the laboratory.

Ambient ozone measurement. The air sample is pressurized to nominally 100 kPa (1 atm) prior to measurement of the ozone level. The ozone readings are corrected for drift of the instrument zero by subtracting the most current zero-level reading. To account for differences in regulated pressure between GASP systems, and to account for variations in the air sample temperature and pressure during flight, the zero-corrected ozone levels are normalized to standard atmospheric pressure and to a temperature of 25 degrees C. Data are not reported if the pressure of the sample entering the ozone instrument is less than aircraft cabin pressure.

The destruction of ozone in the tetrafluoroethylene (TFE) sample lines from the inlet probe to the instrument, and in the TFE-coated diaphragm pump is periodically measured on board the aircraft under conditions simulating operation in flight. The ozone mixing ratio at the probe inlet (O3, in ppbv) is expressed in terms of the measured ozone mixing ratio (O3m, in ppbv) as

$$O3 = (1+a)O3m \qquad (1)$$

with the constant 'a' determined by a regression analysis on the appropriate destruction test data. For the data reported on tape VL0009, the ozone destruction correction was made using a = 0.028. The uncertainty in this approximation is $\pm$ 2 percent. The destruction constants used are given in the FLHT record for each flight (see table A-I).

In previous reports a more complicated form of equation (1) was reported (ref. 10-15) which accounted separately for destruction of ozone by thermal and wall effects. Although the percentage of the incoming ozone destroyed by wall effects decreases with increasing concentrations, the percentage of the incoming ozone destroyed by the thermal mechanism increases with increasing concentration. Since both mechanisms are likely contributing to the system

destruction, it is not surprising that the destruction data are approximated well with a linear relationship which gives a constant percentage destruction.

As mentioned above, reported ozone levels have been corrected for drift of the instrument zero, for differences in the air density between the sampling and laboratory conditions, and for ozone destruction in the sample lines and pump. Zero level data appear in cal cycle 1 and are identified by a 'Z' tag. The density ratio factor is given by RHOR in the DATA records. Ozone data values reported have been calculated as follows:

$$O3 = (1+a)*(RHOR)*(O3r - O3z) \tag{2}$$

where

O3z is the most current zero
O3r is the measured (uncorrected) ozone mixing ratio
RHOR is the density correction
(1+a) is the destruction correction (see Eq. (1))

Three ozone data values are reported in the DATA records (see table A-II). The reading at the time the recording is made is O3. The mean ozone level for the 128 seconds preceding the recording is O3A, and the standard deviation of the measured ozone levels for that period is O3S. Because for some DATA records O3 is available, but O3A and/or O3S are not, all three values are tagged separately. Note that during continuous recordings (MODE = 10, or TYPE = 'L', or TYPE = 'C') O3A = O3S = 0 and their respective tags are set equal to 'M'.

<u>Cabin ozone measurement</u>. During the winter of 1976-77, the Federal Aviation Administration (FAA) received several complaints of physical discomfort on high-altitude flights. In response to suspicions that ozone gas was the probable cause, GASP began, in March 1977, to make measurements of cabin ozone levels on aircraft N4711U and N533PA. The addition of this capability to these GASP systems is providing simultaneous measurements of cabin and ambient ozone on flights of varying duration, and at different flight levels, geographical locations, and seasons. Based on Occupational Safety and Health Administration (OSHA) standards, and analysis of the available data (including analyses of GASP ambient ozone measurements (refs. 22 and 28) and simultaneous cabin and ambient ozone measurements from selected GASP flights (ref. 29)), the FAA has issued a Notice of Proposed Rulemaking (NPRM) regarding acceptable levels of ozone in aircraft cabins (ref. 30).

For the GASP measurement of cabin ozone, the air is

drawn from a 0.62 cm diameter port, located about 1.5 m above the floor on the wall of the staircase to the upper deck in the first class cabin. This port is extended about .62 cm from the wall surface to minimize drawing air from along the wall surface.

Cabin ozone data are processed in a manner directly analogous to that used for the ambient ozone levels. That is, cabin ozone levels (O33, in ppbv) are calculated as follows:

$$O33=(CDENS)*(O33r-O33z) \quad (3)$$

where

O33z is the most current zero
O33r is the measured(uncorrected) ozone mixing ratio
CDENS is the density correction. Assumed air sample temperature=15 deg C at cabin pressure.

Zero level data appear in cal cycle 1, and are identified by a 'Z' tag. The density ratio factor, CDENS, is given in the DATA records for each observation, so that the raw data readings can be extracted and alternate processing schemes employed at the analysts' option.

## Carbon Monoxide

The carbon-monoxide measurement is made with an infra-red absorption analyzer using dual isotope fluorescence. In the dual isotope fluorescence technique, alternating pulses of IR radiation spectra from a single source are produced that are an exact match of the vibrational-rotational absorption bands of $C^{12}O^{16}$ and $C^{13}O^{16}$. These two IR radiation spectra are passed through a single air-sample chamber. The CO present in the air sample (98.9% of all naturally occuring carbon-monoxide is $C^{12}O^{16}$) will absorb the $C^{12}O^{16}$ radiation but not the $C^{13}O^{16}$ radiation. Thus the $C^{13}O^{16}$ radiation pulse is a reference against which the absorption of $C^{12}O^{16}$ can be measured. After passing through the air-sample chamber, the alternating radiation pulses are converted to electrical signals by a solid-state IR detector. Ratio comparison of the two signal levels yields a voltage corresponding to the CO concentration in the air sample.

The air sample, pressurized to 100 kPa (1 atm), passes through a dessicant cartridge to remove water vapor, and through a particulate filter before admission to the air-sample chamber. Inlet pressure and temperature are measured to permit corrections for density effects. Data are normalized to standard atmospheric pressure and to a temperature of 25 degrees C. The analyzer zero-CO

voltage (COz) is monitored at 20 minute intervals by diverting the air sample through a heated, hopcalite scrubber to remove all traces of CO from the air sample. Carbon-monoxide concentrations are corrected for zero drift by subtracting the most current zero-CO voltage as discussed below. The electronic gain of the analyzer is monitored once per hour.

Output of the analyzer is a linear 0 to 5V DC signal corresponding to the CO level of the air sample. Sensitivity, adjusted during calibration, is 250 ppbv per volt. Limit of detectability is 20 ppbv. Because a change in analyzer ambient temperature causes a zero shift, and because the data system cannot accept a negative voltage, the zero-CO level is set at 2V DC. Full scale output thus corresponds to 750 ppbv.

The analyzers are calibrated with CO in nitrogen gas mixtures obtained from the National Bureau of Standards. The CO content of these mixtures is accurately known so as to serve as NBS Standard Reference Materials. The lowest concentration of CO obtainable as an NBS/SRM is about 10 ppmv. Therefore, a precision flow blender is used to dilute this mixture with proportionate amounts of CO-free nitrogen to obtain sample flows in the range of 100 ppbv to 900 ppbv. Calibrations using the diluted NBS/SRM are estimated to be accurate to within ± 2 percent.

Early in the GASP program, calibrations were also performed with nitrogen cylinders whose CO content was determined from a comparison with an NBS/SRM calibration. The use of these span gases for calibration has been discontinued because of the variability of the CO level over a period of time.

Each analyzer is calibrated prior to its installation on an aircraft. A check on this calibration is performed upon its removal to determine any change in sensitivity. Uncertaincy of the CO measurement is the result of calibration errors, change in sensitivity between calibrations, and random fluctuation of the output signal. For the data reported herein, the measurement error is within ± 12 percent of reading due to calibration error and sensitivity change, plus an error of ± 5 ppbv due to random fluctuation of the output signal.

Carbon monoxide data are processed according to the following:

$$CO = .25(RHOR)(COv-COz) \qquad (4)$$

where
COz is the most current zero (mv)

COv is the local CO voltage (mv)
RHOR is the density correction

During the course of each flight, the CO zero level may vary appreciably. Because the data reduction always uses the 'most current' values available, and new COz's are obtained at nominally 20 minute intervals, COz variations can introduce errors in the reported CO mixing ratios. For example, if the true CO mixing ratio is constant, a difference of 100 mv in two consecutive zeros would result in an error of up to 25 ppbv in the reported CO level. To assist in identifying data which may have a significant error due to zero level variation, any COz reading which differs from the previous zero by more than 100 mv has had the normal 'Z' tag replaced with a 'C' tag. CO data readings that occur between 2 zeros that differ by more than 200 mv have been edited out.

Three carbon monoxide data values are reported in the DATA records (see table A-II). The reading at the time the recording is made is CO. The mean carbon monoxide level for the 128 seconds preceding the recording is COA, and the standard deviation of the measured carbon monoxide levels for that period is COSD. Because for some DATA records CO is available, but COA and/or COSD are not, all three values are tagged separately. Note that during continuous recordings (MODE = 10, or TYPE = 'L', or TYPE = 'C') COA = COSD = 0 and their respective tags are set equal to 'M'.

## Condensation Nuclei

The condensation nuclei measurement is made with a modified commercial monitor purchased from Environment/One Corporation of Schenectady, N.Y. Sample air, at a rate of 5 standard liters per minute, is brought from the GASP inlet probe to the monitor thru an 8 meter length of 17 mm I.D. stainless steel tubing. The sample is pressurized to cabin pressure in the monitor and then passes thru the monitor's detector system. The sample leaves the monitor and is exhausted from the aircraft thru the GASP system static overboard exhaust port.

The sample is pressurized to cabin pressure by use of a NASA designed and installed 'Air Piston' type pressurization system. In this system, the sample is drawn into a length of tubing. The tubing is then backfilled with filtered cabin air, thereby trapping the sample at one end of the tube at cabin pressure. The trapped sample is drawn into the detector system for the actual measurement.

In the detector system, the pressurized sample first

passes thru a humidifier and then into a cloud chamber where it is expanded adiabatically. This creates conditions such that the particles act as nucleation sites for the formation of a water droplet cloud. The density of the cloud, assumed to be proportional to the number of particles present, is measured by use of a light attenuation measurement technique. The relationship between particle concentration and light attenuation is obtained thru calibration.

The sensitivity of the monitor detector system is set to 600 (particles/$cm^3$)/volt which results in an approximate full scale range of 1000 particles/$cm^3$ at typical GASP flight conditions. (The data system has a 5 volt full scale range.) Repeated calibrations indicate that the output is linear with concentration and repeatable to within $\pm$ 5% of reading. The overall accuracy of a concentration measurement when including the pressurization system is estimated to be better than $\pm$ 10% of a reading at concentrations greater than 100 particles/$cm^3$ for a given type of particle. Noise level on the monitor's output signal is equivalent to less than $\pm$ 10 particles/$cm^3$ at flight conditions. The time constant (63% change) for a step change in inlet concentration is 6 seconds and is primarily a function of electronic filtering.

A Pollak counter is used as the standard against which the condensation nuclei monitors are calibrated. Combustion products from the burning of cotton string are used as a source of particles for calibration. The monitor has been tested with other types of particles and has shown sensitivity shifts of as much as 25% dependent on particle type. In these tests, particles obtained from heated nichrome wire, atomized 1% NaCl solution and room airborn particles were used.

Reported condensation nuclei data, like the ozone and carbon monoxide data, are corrected for variations in the instrument zero by subtracting the most current zero level. For the CN instrument, these occur on all even calibration cycles, are reported in millivolts, and are identified in the DATA records with a 'Z' tag. Full scale data readings are identified by a 'P' tag.

Four condensation nuclei data values are reported for each DATA record. CNC is the local value at the time of the recording; AVA is the average value over the 240 seconds prior to the recording; ATKMAX is the maximum, and ATKMIN is the minimum of the 12 descrete values used in calculating AVA. All condensation nuclei data values are tagged independently. For continuous recordings (MODE = 10, or TYPE = 'L', or 'C'), AVA, ATKMAX, ATKMIN are set equal to zero, and their respective tags are set equal to 'M'.

The published data obtained from the GASP condensation nuclei measurement system is corrected for the ratio of ambient to cabin air density (DENS in the DATA records) and is therefore the actual particle concentration external to the aircraft. Calculations indicate that diffusion losses which may occur in the 8 meter length of inlet tubing could amount to as much a 3%, 7%, and 45% of the particles present with diameters of 0.02, 0.01, and 0.002 microns respectively. No measurement of the actual losses occuring in the aircraft systems have been made and since the size distribution of the particles being measured is unknown, no corrections for diffusion losses or sensitivity shifts are applied to the published data.

## Cloud Detector and Light Scattering Particles

Flight test experience with the light-scattering particle counters included in the GASP systems (see ref. 3) has indicated that flight through clouds results in a significantly greater count of the largest size particles (D > 3 micrometers) than is obtained in clear air. A simple cloud detector is thus available by observing the counting rate of the largest size particles. This signal is monitored for 256 seconds prior to each data recording. The time (in seconds) during which the cloud rate, CLDRT, is greater than a preset level, CLDHI, is interpreted as time in clouds (CLSEC; see table A-II). The CLDHI level was programmed on board the United airliner based on visual observation of a light haze, and corresponds to a local particle density (for D > 3 micrometers) of 66,000 particles/cubic meter. If CLSEC > 0, CLTAG = 'C'. If cloud data are not available, CLTAG = 'M'.

The number of cloud encounters (CLAYR; see table A-II) is also available. Whenever clouds are detected (CLDRT > CLDHI), this is interpreted as a continuous encounter until cloud-free air is detected. This determination requires a second preset level, CLDLO. If n is the number of times that the cloud rate crosses CLDHI and CLDLO (or CLDLO and CLDHI) in succession, then CLAYR = (n+1)/2. For the data reported herein CLDLO was set at CLDHI/8.

Except for clouds, data from the light scattering particle counters have not been reported previously due to a rather large uncertainty in the total particle count resulting from nonuniform illumination of the sample volume, and high noise-to-signal ratios on channels measuring particles less than 1.4 microns in diameter. However, in response to requests, and as a supplement to the time-in-clouds data, measured particle densities, in particles/ambient cubic meter, are reported for particles > .45, > 1.4, and > 3 microns in diameter. The latter

channel is the one used by the cloud detector, although the particle densities are obtained over a 60 second sampling period, whereas the sampling time for the cloud detection is 256 seconds.

The particle density data reported are subject to variations between instruments due to differences in illumination of the sample volume. Our preliminary indication is that the resultant difference in magnitude may be on the order of ± 1/2 cycle (X or / by a factor of 3). A detailed mapping of the sample volume light field has not been made for any of the instruments flown on GASP B-747's nor has any attempt been made to correct or normalize the data. It should also be noted that the minimum detectable particle density is approximately 30 particles/ambient cubic meter.

Particle density and cloud data are reported when available in the DATA record for each sampling period. There are no calibration cycles for this instrument, so all CYCLES are data. Since a pre-recording sampling period is required for these measurements, data do not appear for continuous recordings (MODE = 10, or TYPE = 'L'). For all flights in which particle or cloud data are reported, the instrument ID number is given in the FLHT records, otherwise PCSID = PCEID = 'M'.

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## FLIGHT AND METEOROLOGICAL DATA

In addition to the air sample measurements, aircraft flight data are obtained with each data recording to precisely describe conditions when the data are acquired. Aircraft position, heading, and the computed wind speed and direction are obtained from the inertial navigation system (INS). Altitude, air speed, and static air temperature are collected from the central air data computer (CADC) in the aircraft. Date and time are provided by a separate GASP clock-calendar unit. The above parameters are obtained once per DATA record. The vertical acceleration of the aircraft is obtained from the aircraft flight recording system at the rate of 8 per second which provides 32 data points for each DATA record. The formats and units for these data are given in table A-II.

The programming for the GASP systems initiates a continuous recording whenever the vertical acceleration of the aircraft exceeds preset limits. This recording then continues until the acceleration has remained within limits for one minute. These limits are currently set at 0.8 and 1.2 G's to correspond to "light-to-moderate" turbulence. Continuous recordings triggered by an acceleration limit are identified by TYPE = 'L', and the number of times (out of

32) that the acceleration has exceeded the limits is given by NE (see table A-II). For any flight during which one or more limit recordings occurred, LIMCHK = 'T' in the FLHT record for that flight (see table A-I).

For each DATA record, the date, time, latitude, and longitude have been used to calculate the solar elevation angle (ref. 31). This is designated as ZEN in table A-II. Note that -90 deg < ZEN < +90 deg, where ZEN = +90 deg if the sun is directly overhead. The flight altitude is used to determine the solar elevation angle at sunrise and sunset, and day and night observations are identified by SUNTAG = ' ' and 'N' respectively. If GMT is not available for a given record (GMTTAG = 'M'), SUNTAG = 'M', and ZEN = 0.

The primary purpose of the flight and meteorological data is to provide supporting information for the constituent measurements. However, these data, particularly the wind and temperature measurements, may be of interest even where constituent data are not available, and therefore are reported for all GASP flights.

## TROPOPAUSE PRESSURE DATA

The National Meteorological Center (NMC) is presently maintaining a library of gridded meteorological data fields. Among these are tropopause pressures, available on a twice daily basis (0000 and 1200 GMT), gridded into a 37 by 144 array for each hemisphere (2.5 degree intervals in both latitude and longitude).

The tropopause pressure corresponding to each GASP data location is obtained by time and space interpolation from the NMC arrays. These pressures and the corresponding geopotential heights for the standard atmosphere are included in the GASP DATA records (TRPRMB and TRPRHM in table A-II). For normal interpolations (within a 12 hour interval) TPTAG = ' '. If however, NMC data are missing for one reporting period such that the interpolation must be performed within a 24 hour interval, TPTAG = 'L'. If NMC data are missing for two or more consecutive reporting periods the time interpolation is not performed. In this case if the time of the GASP data point is within six hours of an NMC reporting period for which data are available, the space interpolated values at that reporting period are returned and TPTAG = 'E', but if the time of the GASP data point is not within 6 hours of an NMC reporting period for which data are available, TRPRMB = TRPRHM = 0, and TPTAG = 'M'. For GASP records in which the observation time is not available, 1200 GMT has been assumed for tropopause interpolation, and TPTAG = 'T'. Whenever tropopause

pressure values are available, DELP = TRPRMB - PAMB, and DELHGT = ALTMAV - TRPRHM are also reported.

Tropopause pressures in the NMC 2-hemisphere arrays are determined by means of the Flattery global analysis method (ref. 32). This procedure makes use of the vertical temperature profiles calculated for each NMC grid point, and tests the slope of the profile curve upwards from the first mandatory pressure level. Although the two hemisphere arrays were not available prior to July 1977, the Flattery analysis scheme was used for tropopause pressures archived in the NMC 65 by 65 arrays prior to December 17, 1975. Tropopause pressures determined by this method have been shown previously to correlate well with GASP constituent data (refs. 9,10,16-22).



## SELECTED ANALYSES

A summary of the GASP data obtained on Pan Am Flight 50 is given in Table II. A time-series presentation, with data averaged over 1/2 hour intervals, is shown in figure 1. Although a detailed analysis of these measurements is beyond the scope of the present report, several features are readily apparent from figure 1 and table II. Namely, the polar legs (SFO-LHR and CPT-AKL) were flown almost entirely in the stratosphere, as indicated by the comparison between the flight altitude and the NMC tropopause height. These flights are characterized by the presence of high ambient ozone, low carbon monoxide, low condensation nuclei, and the absence of clouds. The tropical legs (LHR-CPT and AKL-SFO) were flown almost entirely in the troposphere, and are characterized by low ambient ozone, high carbon monoxide, high condensation nuclei, and frequent cloudiness.

These general characteristics are even more evident in figure 2, where the observations have been grouped with respect to the pressure difference between the flight altitude and the NMC tropopause. Since this figure is comparing the tropical troposphere with the polar stratosphere, and since the data base is for only a 2 day period, these results must not be interpreted as representing global mean conditions.

In addition to the GASP ambient constituent measurements, the ozone level in the aircraft cabin was measured on all segments of Flight 50. These data are shown in figure 3 (again averaged over 1/2 hour intervals). Clearly, the cabin ozone levels were low on all segments. On the dates of these flights, aircraft N533PA was equipped with a charcoal filter system which was evidently very effective in destroying ozone as the aircraft flew through high ambient ozone levels on both polar segments, and the average ratio

of cabin to ambient ozone was only 8.5%. This protection would, of course, not have been necessary on the tropical segments since high ambient ozone was never encountered. The ratio of cabin to ambient ozone was calculated for only those data points for which the ambient level was greater than 100 ppbv.

## CONCLUDING REMARKS

Atmospheric constituent data and related flight and meteorological data obtained during 4 flights of GASP-equipped aircraft N533PA from October 28-31, 1977 are now available. These data may be obtained on GASP tape VL0009 from the National Climatic Center, Federal Building, Asheville, NC, 28801. Flight routes and dates, instrumentation, data processing procedures, and data tape specifications and formats are discussed in this report.

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## APPENDIX A - Specifications for GASP Archive Tapes (VLXXXX)

### GENERAL

1. Tapes are written in EBCDIC format using nine track tapes.
2. Tape density is 800 BPI.
3. Physical records (blocks) are 4096 bytes.
4. The tapes are unlabeled, and contain one or more GASP data files. (On tapes < VL0009 these are followed by a tropopause pressure data file.)

### GASP DATA FILE

1. Each GASP data file contains data from a single GASP aircraft. Within each file, data are grouped and identified by flights (takeoff to landing) in chronological order.
2. The GASP data for each flight begins with a logical FLHT record (flight identification data), which is followed by logical DATA records (one for each data recording made during the flight). Both FLHT and DATA records contain 512 bytes, hence there are 8 logical records per physical record (block).
3. An FLHT record will always be the first logical record in a block. However, every block need not begin with an FLHT record (i.e., if there are more than seven DATA records in a flight). If the FLHT record plus the available DATA records for a flight do not fill an integer number of blocks, the unused logical records in the final block are padded with zeros creating PADD records. The diagram below shows how several short flights would be blocked.

| Block | 1 | | | | | | | | 2 | | | | | | | | 3 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F | D | D | D | D | D | P | P | F | D | D | D | D | D | D | D | D | D | P | P | P | P | P | P |
| Logical Record | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

| Block | 4 | 5 | 6 |
|---|---|---|---|
| | F D D D D D D D | D D D D D D D D | F D D D D D D P |
| Logical Record | 1 2 3 4 5 6 7 8 | 1 2 3 4 5 6 7 8 | 1 2 3 4 5 6 7 8 |

where F is an FLHT record
D is a DATA record
P is a PADD record

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4. The first four bytes in each logical record identify the record type as FLHT, DATA, or PADD. Detailed specification of the parameters and formats for FLHT and DATA records are given in Table A-I and A-II respectively.

   a) In each FLHT record, the number of DATA records to follow is given by NDATA (Bytes 78-81), and the number of blocks in the flight is given by NBLOCK (Bytes 82-84).
   b) For the last DATA record of each flight, LBFLG (Byte 5) = 'L'; for the last DATA record in each file, LBFLG = 'G' if the following file is a GASP data file, and LBFLG = 'T' if the following file is the tropopause pressure file; for all other DATA records, LBFLG = ' '.

   Note: DATA records with LBFLG ≠ ' ' will be followed by PADD records if the physical record (block) is not complete.

Table A-I Format for FLHT Records

| Bytes | Fortran Name | Fortran Format | Parameter Description, Units, and Comments |
|---|---|---|---|
| 1-4 | RECID | A4 | RECID = 'FLHT' |
| 5-10 | TAPID | A6 | Original GASP tape number, GPXXX |
| 11-25 | ACID | A15 | Aircraft ID; Airline and tail number |
| 26-28 | APTLV | A3 | Airport of departure (3 letter code) |
| 29-34 | DATLV | 3I2 | Date first DATA record this flight; Mo=29-30,Da=31-32,Yr=33-34 |
| 35-38 | TIMLV | 2A2 | Time (GMT) first DATA record this flight; Hr=35-36,Min=37-38 |
| 39-43 | LATLV | F5.2 | Latitude (deg) of APTLV |
| 44 | LALVT | A1 | Hemisphere of LATLV; 'N' or 'S' |
| 45-50 | LONLV | F6.2 | Longitude (deg) of APTLV |
| 51 | LOLVT | A1 | Hemisphere of LONLV; 'E' or 'W' |
| 52-54 | APTAR | A3 | Airport of arrival (3 letter code) |
| 55-60 | DATAR | 3I2 | Date last DATA record this flight; Mo=55-56,Da=57-58,Yr=59-60 |
| 61-64 | TIMAR | 2A2 | Time (GMT) last DATA record this flight; Hr=61-62,Min=63-64 |
| 65-69 | LATAR | F5.2 | Latitude (deg) of APTAR |
| 70 | LAART | A1 | Hemisphere of LATAR, 'N' or 'S' |
| 71-76 | LONAR | F6.2 | Longitude (deg) of APTAR |
| 77 | LOART | A1 | Hemisphere of LONAR, 'E' or 'W' |
| 78-81 | NDATA | I4 | Number of DATA records for this flight - see OVRFLO, byte 508 |
| 82-84 | NBLOCK | I3 | Total number of blocks for this flight - see OVRFLO, byte 508 |
| 85-87 | O3ID | A3 | Ozone instrument ID number* |
| 88-90 | COID | A3 | Carbon monoxide instrument ID number* |
| 91-93 | PCSID | A3 | Particle counter sensor ID number* |
| 94-96 | PCEID | A3 | Particle counter electronics ID number* |
| 97-99 | H2OID | A3 | Water vapor sensor ID number* |
| 100-102 | HYGID | A3 | Hygrometer ID number* |
| 103-105 | CNID | A3 | Condensation nuclei instrument ID number* |
| 106-117 | | 4A3 | Spares |

Table A-I Continued

| Bytes | Fortran Name | Fortran Format | Parameter Description, Units, and Comments |
|---|---|---|---|
| 118-122 | D1 | F5.3 | Smallest particle radius (micrometers) for PC range 1 |
| 123-127 | D2 | F5.3 | Smallest particle radius (micrometers) for PC range 2 |
| 128-132 | D3 | F5.3 | Smallest particle radius (micrometers) for PC range 3 |
| 133-137 | D4 | F5.3 | Smallest particle radius (micrometers) for PC range 4 |
| 138-142 | D5 | F5.3 | Smallest particle radius (micrometers) for PC range 5 |
| 143 | LIMCHK | A1 | LIMCHK='T' if acceleration limit exceeded (NE>0) on any DATA record this flight; otherwise LIMCHK='F' |
| 144 | FILEX | A1 | FILEX='T' if filter exposed this flight; otherwise FILEX='F' |
| 145 | FDATA | A1 | FDATA='T' if filter data on tape; otherwise FDATA='F' |
| 146-149 | FPAKN | I4 | Filter pack number |
| 150-151 | FILTN | I2 | Filter number |
| 152-161 | FTYPE | A10 | Filter type |
| 162-167 | FDATON | 3I2 | Filter exposure start date; Mo=162-163,Da=164-165,Yr=166-167 |
| 168-171 | FTIMON | 2A2 | Filter exposure start time; (GMT); Hr=168-169,Min 170-171 |
| 172-176 | FLATON | F5.2 | Filter exposure start latitude (deg) |
| 177 | FLAONT | A1 | Filter exposure start latitude tag; 'N' or 'S' |
| 178-183 | FLONON | F6.2 | Filter exposure start longitude (deg) |
| 184 | FLOONT | A1 | Filter exposure start longitude tag; 'E' or 'W' |
| 185-190 | FHTMON | F6.0 | Filter exposure start altitude (meters) |
| 191-196 | FDATOF | 3I2 | Filter exposure stop date; Mo=191-192,Da=193-194,Yr=195-196 |
| 197-200 | FTIMOF | 2A2 | Filter exposure stop time (GMT); Hr=197-198,Min=199-200 |
| 201-205 | FLATOF | F5.2 | Filter exposure stop latitude (deg) |
| 206 | FLAOFT | A1 | Filter exposure stop latitude tag; 'N' or 'S' |
| 207-212 | FLONOF | F6.2 | Filter exposure stop longitude (deg) |
| 213 | FLOOFT | A1 | Filter exposure stop longitude tag; 'E' or 'W' |
| 214-219 | FHTMOF | F6.0 | Filter exposure stop altitude (meters) |

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Table A-I Continued

| Bytes | Fortran Name | Fortran Format | Parameter Description, Units, and Comments |
|---|---|---|---|
| 220-229 | FCOMP1 | A10 | Filter constituent 1 (name) |
| 230-239 | FCOMP2 | A10 | Filter constituent 2 " |
| 240-249 | FCOMP3 | A10 | Filter constituent 3 " |
| 250-259 | FCOMP4 | A10 | Filter constituent 4 " |
| 260-269 | FCOMP5 | A10 | Filter constituent 5 " |
| 270-279 | FDC1 | F10.3 | Data for constituent 1 (micrograms/m**3) |
| 280-289 | FDC2 | F10.3 | Data for constituent 2 (micrograms/m**3) |
| 290-299 | FDC3 | F10.3 | Data for constituent 3 (micrograms/m**3) |
| 300-309 | FDC4 | F10.3 | Data for constituent 4 (micrograms/m**3) |
| 310-319 | FDC5 | F10.3 | Data for constituent 5 (micrograms/m**3) |
| 320 | SBUEX | A1 | SBUEX='T' if MODE=10 recording this flight; otherwise SBUEX='F' |
| 321 | | A1 | Spares** |
| 322-324 | | I3 | Spares** |
| 325-332 | | 4I2 | Spares** |
| 333-336 | | 2A2 | Spares** |
| 337-341 | | F5.2 | Spares** |
| 342 | | A1 | Spares** |
| 343-348 | | F6.2 | Spares** |
| 349 | | A1 | Spares** |
| 350-355 | | F6.0 | Spares** |
| 356-361 | | 3I2 | Spares** |
| 362-365 | | 2A2 | Spares** |
| 366-370 | | F5.2 | Spares** |
| 371 | | A1 | Spares** |
| 372-377 | | F6.2 | Spares** |
| 378 | | A1 | Spares** |

Table A-I Completed

| Bytes | Fortran Name | Fortran Format | Parameter Description, Units, and Comments |
|---|---|---|---|
| 379-384 | | F6.0 | Spares** |
| 385-434 | | 5A10 | Spares** |
| 435-444 | FFLO | F10.1 | Filter flow in ambient cubic meters** |
| 445-484 | | 4F10.1 | Spares** |
| 485-489 | a | F5.3 | O3 destruction constant (see eq. 1) |
| 490-494 | b | F5.3 | O3 destruction constant (see eq. 1) |
| 495-499 | c | F5.1 | O3 destruction constant (see eq. 1) |
| 500-507 | d | E8.2 | O3 destruction constant (see eq. 1) |
| 508 | OVRFLO | I1 | If OVRFLO>0, NDATA=NDATA+OVRFLO*7992, and NBLOCK=NBLOCK+OVRFLO*1000 |
| 509-512 | SENS | F4.2 | Carbon monoxide sensitivity correction factor |

* If ID='M', no data for this instrument this flight

** Used on tapes VL0004, VL0005, and VL0006 for reporting data from "grab" sample bottle exposures - see TM X-73574, TM X-73608, and TM 73727

Table A-II Format for DATA Records

| Bytes | Fortran Name | Fortran Format | Parameter Description, Units, and Comments |
|---|---|---|---|
| 1-4 | RECID | A4 | RECID= 'DATA' |
| 5 | LBFLG | A1 | LBFLG='L' if this is the last data record this flight;<br>LBFLG='G' if this is the last GASP data record in the file and the following file is a GASP data file;<br>LBFLG='T' if this is the last GASP data record in the file and the following file is a tropopause pressure file;<br>otherwise LBFLG=' ' |
| 6-9 | RECORD | I4 | Record number on TAPID* |
| 10 | FRAME | I1 | Frame number on TAPID* |
| 11-12 | MODE | I2 | Program mode*: = 4 - normal recordings<br>= 10 - continuous recordings |
| 13 | TYPE | A1 | Record type*: = 'N' for normal recordings<br>= 'L' for continuous limit recordings<br>= 'C' for continuous recordings** |
| 14 | CYCLE | A1 | Calibration cycle number, or CYCLE='D' for data; cal and data cycles alternate at 5 min intervals, unless MODE = 10 or TYPE = 'L' |
| 15-20 | DATE | 3I2 | Mo=15-16, Da=17-18, Yr=19-20 |
| 21-24 | TIME | 2A2 | Time (GMT), Hr=21-22, Min=23-24 |
| 25-30 | ALTFAV | F6.0 | Pressure altitude (ft) |
| 31-36 | ALTMAV | F6.0 | Pressure altitude (meters) - see ALTAG, byte 44 |
| 37-43 | PAMB | F7.2 | Ambient static pressure in hPa - calc from ALTFAV |
| 44 | ALTAG | A1 | ALTAG='C', 'D', or 'G' indicates climb, descent, or ground<br>If ALTAG='T', ALTMAV and TRPFHM are geopotential heights (m) |
| 45-49 | LAT | F5.2 | Latitude (deg) |
| 50 | LATAG | A1 | Latitude hemisphere, 'N' or 'S' |
| 51-56 | LONG | F6.2 | Longitude (deg) |
| 57 | LONGTAG | A1 | Longitude hemisphere, 'E' or 'W' |

Table A-II Continued

| Bytes | Fortran Name | Fortran Format | Parameter Description, Units, and Comments |
|---|---|---|---|
| 58-62 | XI | F5.2 | Aircraft position in NMC grid coordinates |
| 63-67 | YJ | F5.2 | Aircraft position in NMC grid coordinates |
| 68-71 | HEADG | F4.0 | Aircraft heading (deg) |
| 72 | HEADGT | A1 | Tag for HEADG** |
| 73-76 | TASK | F4.0 | True airspeed (knots) |
| 77-81 | XMATAS | F5.3 | Flight mach number |
| 82 | TATAG | A1 | Tag for TASK and XMATAS** |
| 83-86 | WS | F4.0 | Wind speed (knots) |
| 87-90 | WSM | F4.0 | Wind speed (meters/sec) |
| 91 | WSTAG | A1 | Tag for WS and WSM** |
| 92-95 | WDEG | F4.0 | Wind direction (deg) |
| 96 | WDEGTG | A1 | Tag for WDEG** |
| 97-100 | SAT | F4.0 | Static (ambient) air temperature (deg C) |
| 101 | SATAG | A1 | Tag for SAT** |
| 102-229 | ACC(I) | 32F4.2 | Vertical acceleration (G's); 32 values each record at 8/sec |
| 230-233 | ACCMAX | F4.2 | Max of ACC(I) |
| 234-237 | ACCMIN | F4.2 | Min of ACC(I) |
| 238-239 | NE | I2 | Number of times ACC(I) > 1.2 or ACC(I) < 0.8 |
| 240 | ACCTAG | A1 | Tag for ACC(I), ACCMAX, ACCMIN, NE** |
| 241-245 | ZEN | F5.1 | Solar elevation angle (deg); 0 deg = horizontal |
| 246 | SUNTAG | A1 | SUNTAG='N' if sun below horizon** |
| 247-252 | O3 | F6.0 | Ozone data (ppbv) |
| 253 | O3TAG | A1 | Tag for O3** |
| | | | If O3TAG='Z', O3 = instrument zero (ppbv) - see text |
| 254-259 | O3A | F6.0 | Ozone ave (ppbv); for 128 sec preceding recording |
| 260 | O3ATAG | A1 | Tag for O3A** |
| 261-266 | O3S | F6.0 | Ozone std deviation (ppbv); for 128 sec preceding recording |
| 267 | O3STAG | A1 | Tag for O3S** |

Table A-II Continued

| Bytes | Fortran Name | Fortran Format | Parameter Description, Units, and Comments |
|---|---|---|---|
| 268-273 | DFPTA | F6.1 | Dew/frost point temperature (deg C) |
| 274-279 | WVMRA | F6.1 | Water vapor mixing ratio (ppmw) |
| 280 | DFTAGA | A1 | Tag for DFPTA and WVMRA; if DFPTA ≥ SAT, DFTAGA='S'** |
| 281-286 | COAVG | F6.0 | Carbon monoxide data (ppbv) |
| 287 | COTAGA | A1 | Tag for COAVG**<br>If COTAGA='Z', COAVG = instrument zero (mv) - see text<br>If COTAGA='G', COAVG = instrument gain (mv) - see text |
| 288-293 | COA | F6.0 | Carbon monoxide ave (ppbv); for 128 sec preceding recording |
| 294 | COATAG | A1 | Tag for COA** |
| 295-300 | COSD | F6.0 | Carbon monoxide std deviation (ppbv);<br>for 128 sec preceding recording |
| 301 | COSTAG | A1 | Tag for COSD** |
| 302-311 | PD1 | 1PE10.3 | Particle density for particles > D1 (particles/m**3) |
| 312 | PDTAG1 | A1 | Tag for PD1** |
| 313-322 | PD2 | 1PE10.3 | Particle density for particles > D2 (particles/m**3) |
| 323 | PDTAG2 | A1 | Tag for PD2** |
| 324-333 | PD3 | 1PE10.3 | Particle density for particles > D3 (particles/m**3) |
| 334 | PDTAG3 | A1 | Tag for PD3** |
| 335-344 | PD4 | 1PE10.3 | Particle density for particles > D4 (particles/m**3) |
| 345 | PDTAG4 | A1 | Tag for PD4** |
| 346-355 | PD5 | 1PE10.3 | Particle density for particles > D5 (particles/m**3) |
| 356 | PDTAG5 | A1 | Tag for PD5** |
| 357-361 | CLSEC | F5.0 | Time in clouds (sec) during 255 sec preceding recording |
| 362-365 | CLAYR | F4.0 | Number of cycles in and out of clouds (layers)<br>during 255 sec preceding recording |
| 366 | CLTAG | A1 | Tag for CLSEC and CLAYR; if CLSEC > 0, CLTAG='C'** |
| 367-373 | TRPRMB | F7.2 | Tropopause pressure in hPa (mb);<br>time and space interpolated from NMC data fields+ |

Table A-II Continued

| Bytes | Fortran Name | Fortran Format | Parameter Description, Units, and Comments |
|---|---|---|---|
| 374 | TPTAG | A1 | Tag for tropopause data+ |
| | | | If TPTAG=' ', TRPRMB from 12 hour interpolation |
| | | | If TPTAG='L', TRPRMB from 24 hour interpolation |
| | | | If TPTAG='E', TRPRMB from nearest NMC reporting period |
| | | | If TPTAG='T', TRPRMB from 1200 GMT reporting period # |
| | | | If TPTAG='M', data not available |
| 375-381 | DELP | F7.2 | DELP = TRPRMB - PAMB, in hPa (mb)+ |
| 382-387 | TRPRHM | F6.0 | Tropopause height in meters+ |
| | | | If ALTAG≠'T', TRPRHM from TRPRMB assuming std. atm. |
| | | | If ALTAG='T', TRPRHM interpolated from NMC data fields |
| 388-394 | DELHGT | F7.0 | DELHGT = ALTFAV*.3048 - TRPRHM, in meters, |
| | | | where TRPRHM from TRPRMB assuming std. atm.+ |
| 395 | GMTTAG | A1 | Tag for TIME** ++ |
| 396-401 | CNC | F6.0 | Condensation nuclei data; number/cc |
| 402 | CNTAG | A1 | Tag for CNC** |
| | | | If CNTAG='Z', CNC = instrument zero (mv) - see text |
| 403-408 | AVA | F6.0 | Condensation nuclei data; number/cc - |
| | | | average over 240 sec prior to recording - see text |
| 409 | AVATAG | A1 | Tag for AVA** |
| 410-415 | ATKMAX | F6.0 | Max condensation nuclei (number/cc) |
| | | | during 240 sec period for AVA - see text |
| 416 | AMXTAG | A1 | Tag for ATKMAX** |
| 417-422 | ATKMIN | F6.0 | Min condensation nuclei (number/cc) |
| | | | during 240 sec period for AVA - see text |
| 423 | AMNTAG | A1 | Tag for ATKMIN** |
| 424-428 | RHOR | F5.3 | Density ratio correction used in |
| | | | processing O3 and CO data - see text |

Table A-II Completed

| Bytes | Fortran Name | Fortran Format | Parameter Description, Units, and Comments |
|---|---|---|---|
| 429-433 | DENS | F5.3 | Density ratio correction used in processing CN data - see text |
| 434-440 | 033 | F7.0 | Inside (Cabin) ozone; ppbv |
| 441 | 033TAG | A1 | Tag for 033 |
| 442-446 | CDENS | F5.3 | Density ratio correction used in processing 033 data - see text |
| 447-452 | RPFLOM | F6.2 | Conversion from particle counts to particle density |
| 453-456 | | I4 | Spares |
| 457-460 | | I4 | Spares |
| 461-512 | | 52A1 | Spares |

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* Each recording period is 16 sec in duration with 4 frames/record; only 1 frame from each recording period is reported unless MODE = 10 or TYPE = 'L' or 'C'.

** If TAG='M', corresponding data field will be zero; the 'M' tag is used whenever data are not available, have been edited out, or an instrument is in a calibration cycle which is not used directly in the data processing.

\+ Added beginning with VL0004 to provide time and space interpolated tropopause data

++ Added beginning with VL0006 to identify records for which GMT is not available

\# Added beginning with VL0007 to identify tropopause data obtained from 1200 GMT arrays when GASP GMT is not available

\## Added beginning with VL0009 to identify continuous recordings with normal cal/data cycling - see CYCLE, byte 14.

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TABLE I - GASP DATA ON TAPES VL0001-VL0008

| Tape | File | Aircraft | Dates | FLHT* | DATA+ | Data** | Ref |
|---|---|---|---|---|---|---|---|
| VL0001 | 1 | N655PA | 3/11/75- 3/30/75 | 43 | 1919 | O | 9 |
| VL0002 | 1 | N4711U | 3/23/75-10/21/75 | 159 | 7274 | O,W | 10 |
| VL0003 | 1 | N655PA | 5/02/75- 5/30/75 | 49 | 2173 | O | 11 |
| VL0004 | 1 | N4711U | 12/26/75- 3/07/76 | 73 | 3572 | O,W,F | 12 |
| | 2 | N655PA | 1/22/76- 3/25/76 | 66 | 3757 | O,F,B | 12 |
| VL0005 | 1 | N4711U | 3/29/76- 5/29/76 | 100 | 4892 | O,W | 13 |
| | 2 | N655PA | 3/25/76- 5/13/76 | 86 | 4716 | O,B | 13 |
| | 3 | N533PA | 4/13/76- 6/13/76 | 28 | 2640 | O,B | 13 |
| VL0006 | 1 | N655PA | 7/11/76- 9/26/76 | 131 | 8724 | O,F,B | 14 |
| | 2 | N533PA | 7/08/76- 9/14/76 | 45 | 3594 | O,B | 14 |
| | 3 | VH-EBE | 7/13/76- 8/31/76 | 69 | 3977 | O | 14 |
| VL0007 | 1 | N712NA | 10/28/76-11/18/76 | 14 | 3481 | O | 15 |
| | 2 | N4711U | 11/24/76-12/30/76 | 75 | 3756 | O,F | 15 |
| | 3 | N533PA | 9/30/76- 1/02/77 | 146 | 13773 | O,W | 15 |
| VL0008 | 1 | N655PA | 10/15/76- 1/10/77 | 165 | 10122 | F | 15 |
| | 2 | VH-EBE | 9/26/76- 1/09/77 | 286 | 15525 | | 15 |

* Number of flights
\+ Number of DATA records
** Constituent measurements: O - Ozone
W - Water vapor
F - Filter data
B - Sample bottle data

TABLE II - SUMMARY OF GASP DATA ON TAPE VL0009

| FILE | 1 | 2 | 3 | 4 | ALL |
|---|---|---|---|---|---|
| FROM-TO | SFO-LHR | LHR-CPT | CPT-AKL | AKL-SFO | SFO-SFO |
| DATA ACQUISITION | | | | | |
| NDATA | 9162 | 8890 | 11487 | 9640 | 39179 |
| START DATE | 28 | 29 | 29 | 30 | |
| START GMT | 2105 | 1023 | 2324 | 1539 | |
| DURATION, HOURS | 10.67 | 10.62 | 13.43 | 11.07 | 45.78 |
| AMBIENT O3 | | | | | |
| NDATA | 5424 | 5166 | 7013 | 3735 | 21338 |
| AVE, ppbv | 340 | 72 | 378 | 42 | 219 |
| CABIN O3 | | | | | |
| NDATA | 5385 | 5011 | 6991 | 5419 | 22806 |
| AVE, ppbv | 34 | 7 | 27 | 4 | 19 |
| CARBON MONOXIDE | | | | | |
| NDATA | 2373 | 2534 | 3464 | 2771 | 11142 |
| AVE, ppbv | 61 | 94 | 54 | 74 | 69 |
| CONDENSATION NUCLEI | | | | | |
| NDATA | 3872 | 3773 | 4976 | 4272 | 16893 |
| AVE, /cc | 34 | 250 | 26 | 175 | 116 |
| CLOUDS | | | | | |
| NDATA | 117 | 118 | 150 | 129 | 514 |
| OBSERVATION PERIOD, HOURS | 8.32 | 8.39 | 10.67 | 9.17 | 36.55 |
| AVE, percent | .6 | 5.5 | .2 | 6.9 | 3.2 |

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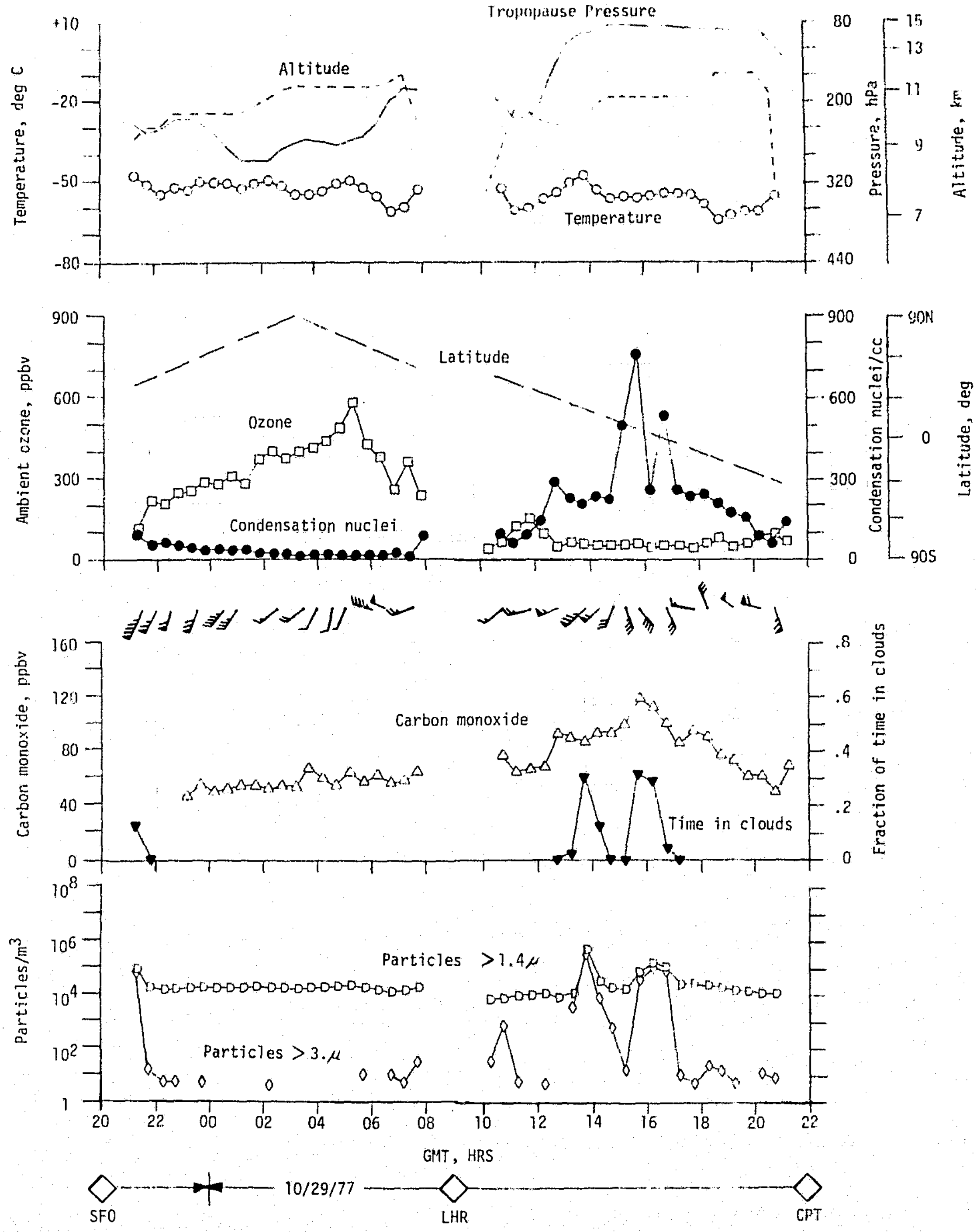
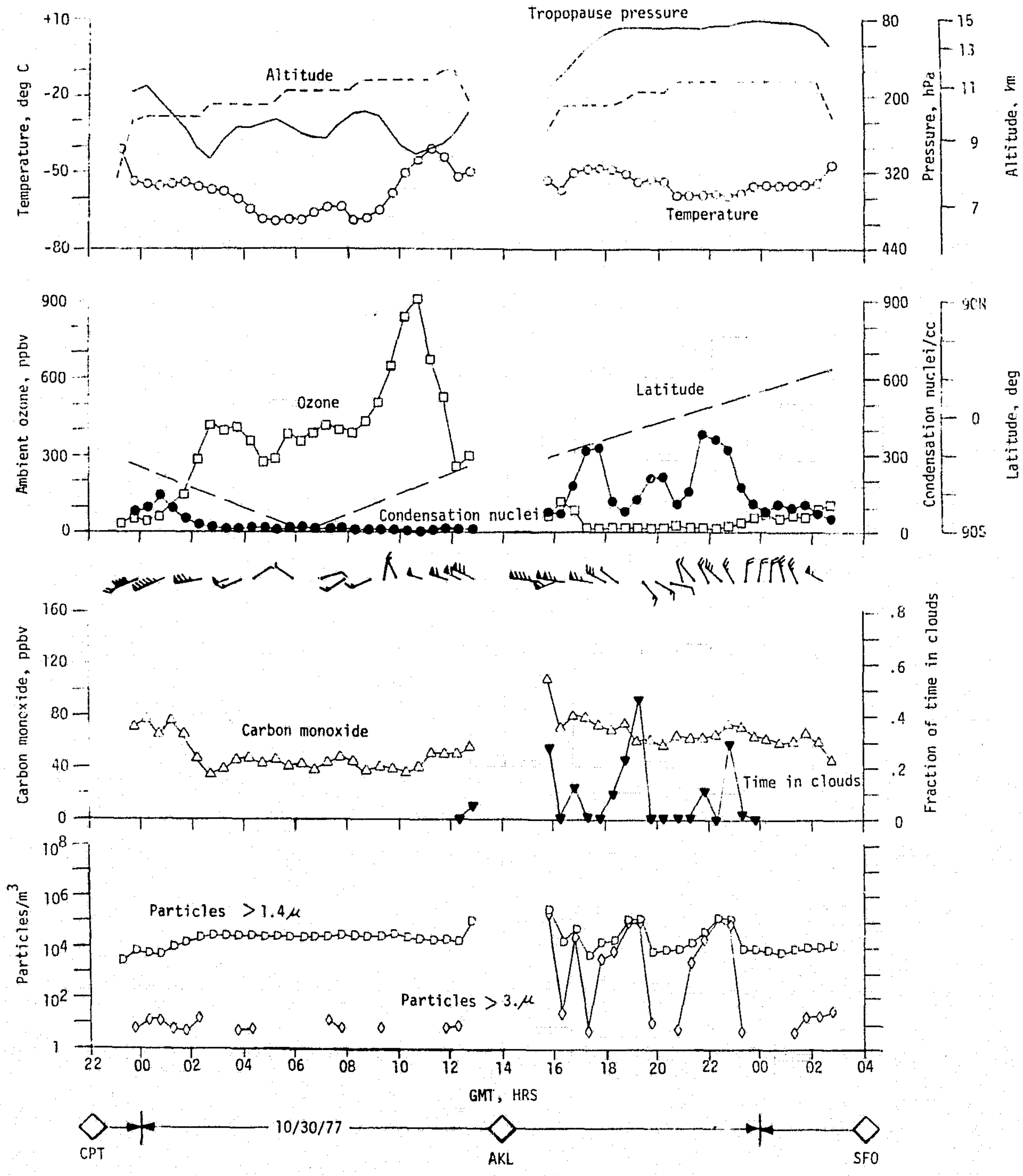



a). SFO-LHR-CPT

Figure 1. Flight record from Pan American World Airways 50th Anniversary Flight, October 28 - 31, 1977. Ozone, carbon monoxide, condensation nuclei, particles, clouds, winds, temperature, latitude, and altitude data were obtained by GASP and aircraft systems. Tropopause pressures were time and space interpolated from NMC data archives. Wind barbs follow standard NWS plotting conventions (speed in knots). All data have been averaged over 1/2 hr. intervals.



b). CPT-AKL-SFO

Figure 1. Concluded.

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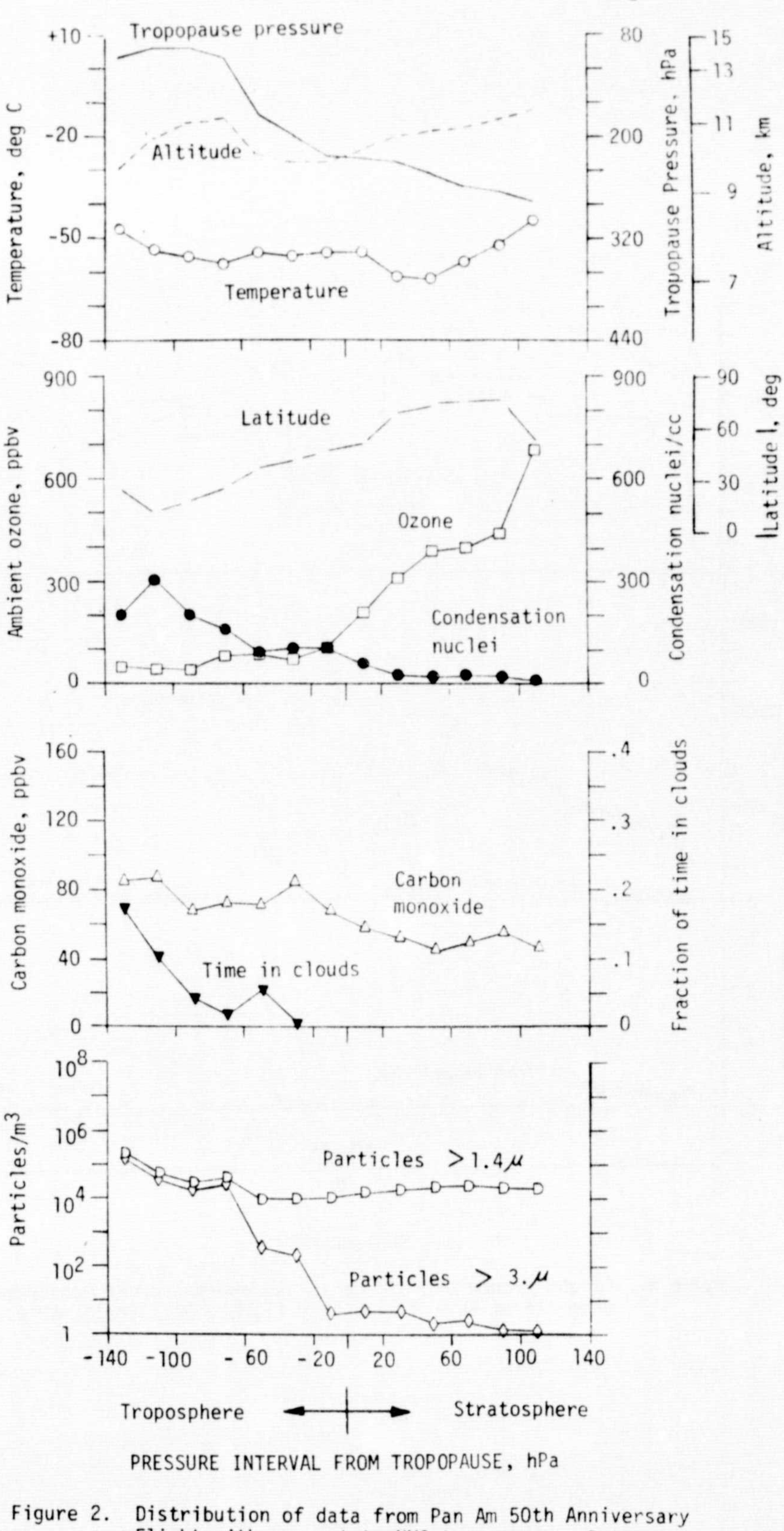
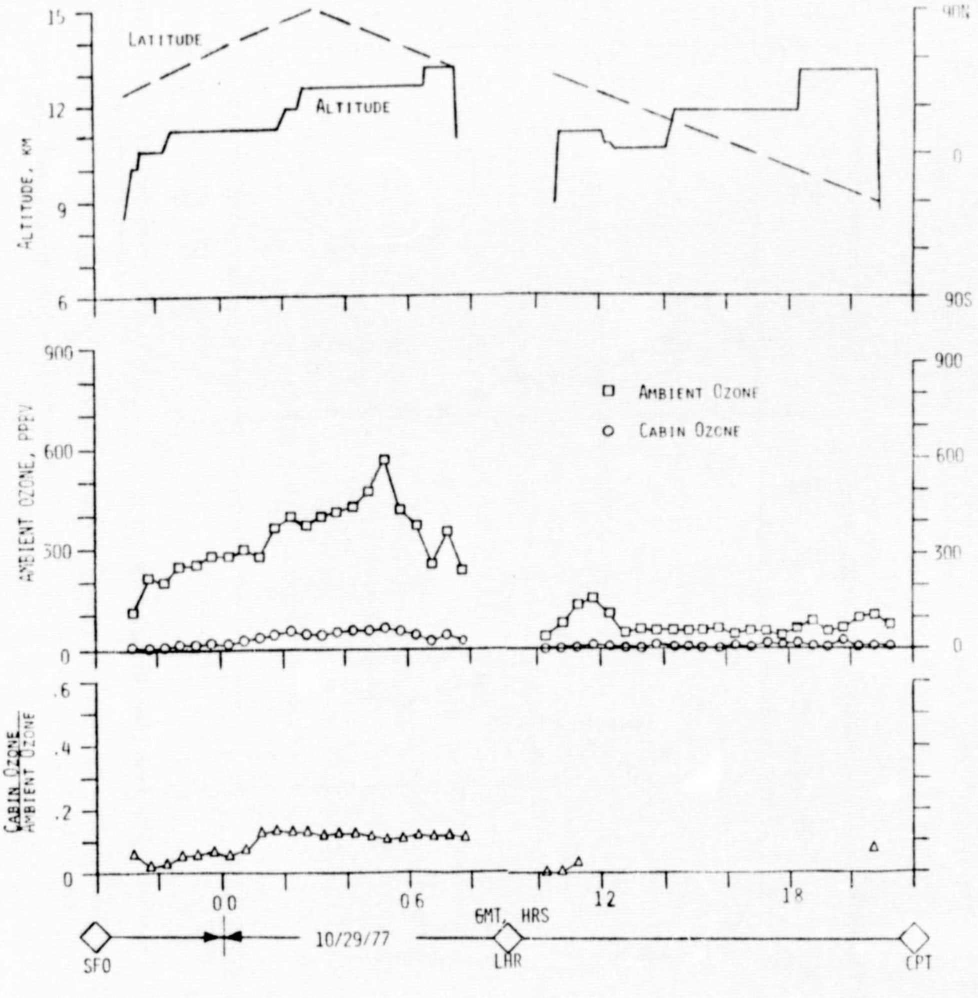



Figure 2. Distribution of data from Pan Am 50th Anniversary Flight with respect to NMC tropopause. Data averaged over 20 hPa intervals.




a) SFO-LHR-CPT

Figure 3. Flight record of GASP cabin and ambient ozone measurements from Pan Am 50th Anniversary Flight, Oct. 28-31, 1977.

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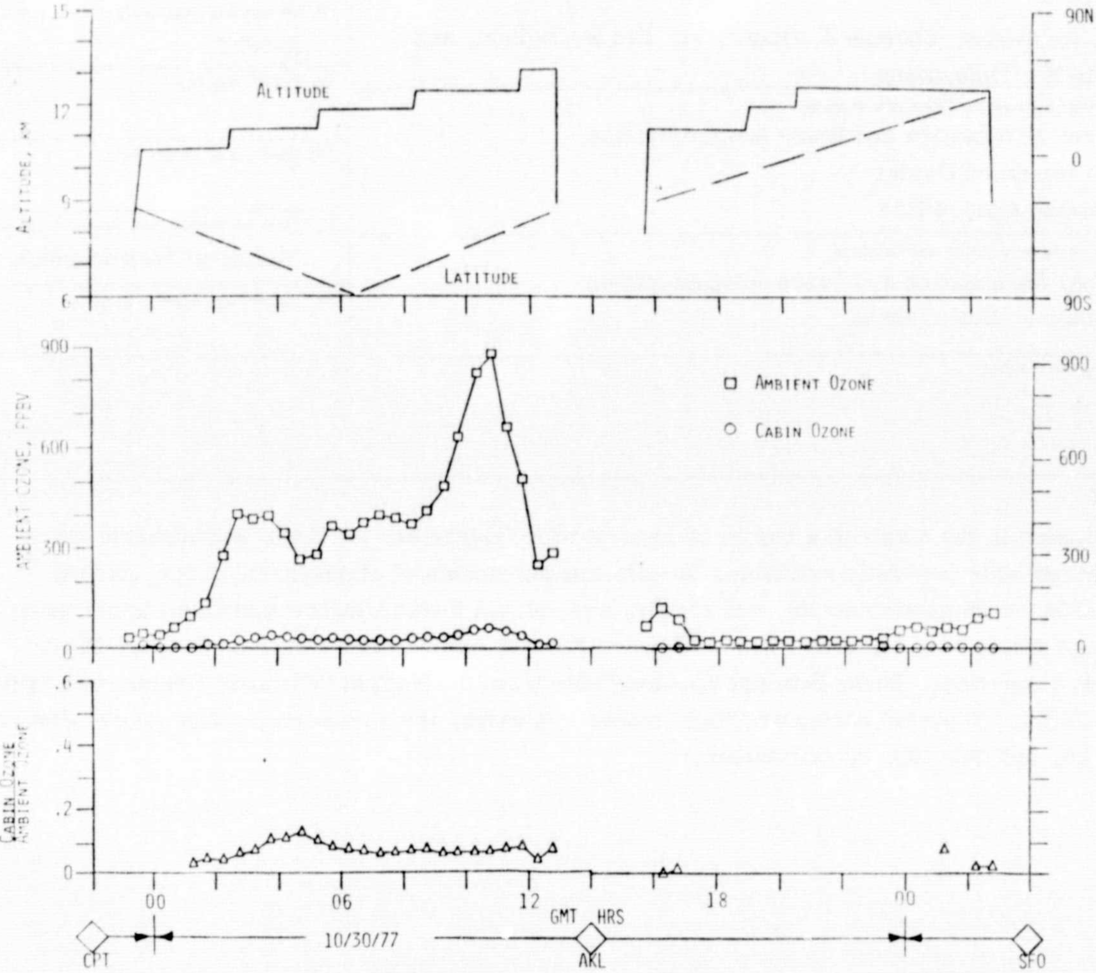


b) CPT-AKL-SFO

Figure 3. Concluded.